

Forces and Motion

PS-5 The student will demonstrate an understanding of the nature of forces and motion.

PS-5.10 Explain how the gravitational force between two objects is affected by the mass of each object and the distance between them.

Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Key Concepts:

Newton's Law of Universal Gravitation

Previous/Future knowledge: In the 8th grade students explained how gravitational forces are influenced by mass and distance (8-4.6). In Physical Science students will understand the new concept that all objects exert forces on all other objects.

It is essential for students to understand

- *Newton's Law of Universal Gravitation* states that there is a force of attraction between all objects in the universe.
- The Law of Universal Gravitation applies to all objects.
- The size of the gravitational force of attraction between two objects depends on the **mass of both objects** and the **distance** between objects.
 - The force is greater when the mass of either of the two objects is greater.
 - Earth, with its huge mass, has a relatively large attractive force with all of the objects near its surface.
 - The moon has less mass than Earth, so the moon has less attraction for objects on its surface than Earth does. (Objects on the surface of the moon weigh less than on Earth because the gravitational force between the object and the moon is less than the gravitational force between the object and the Earth.)
 - The reason the attraction is not noticed between ordinary sized objects that are on earth is that the force that Earth exerts on objects is so great relative to the force of attraction between other objects. (negligible relative to the attraction of the object to Earth).
 - The closer the two objects are, the greater the force
 - When an object, such as a space vehicle, moves away from Earth, the gravitational attraction between Earth and the vehicle becomes less and less.
- That if the force acting on a falling object is the same as the force acting on Earth, the object accelerates toward Earth while Earth doesn't seem to accelerate at all. This is because the mass of Earth is so huge, the force causes only a very tiny acceleration, one that is undetectable by humans.

It is not essential for students to

- Understand the equation that represents Newton's Law of Universal Gravitation.
- Use Newton's Law of Universal Gravitation to solve any problems quantitatively.
- Understand the "inverse square" relationship of force and distance.
- Understand the significance of the Gravitation constant.

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Assessment Guidelines:

The objective of this indicator is to explain how gravitational force is affected by mass and distance, therefore, the primary focus of assessment should be to construct a cause and effect model showing the effect of the mass of any two objects and the distance between the objects has on gravitational force between the objects. Students should construct cause and effect models that explain the behavior of familiar objects (falling objects, weight on the moon) in terms of the gravitational model.

In addition to *explain*, assessments may require that students

- Exemplify how mass and distance influence the magnitude of gravitational force;
- Compare the relative gravitational force of two sets of objects with different masses or the relative gravitational force of sets of objects with different distances between them;
- Identify which object would exert the greatest force depending on its mass or proximity to other objects;
- Summarize the factors that affect gravitational force;
- Illustrate with words, pictures, or diagrams the Law of Universal Gravitation.